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MARCH 2, 1987

CHEMICAL & ENGINEERING

NEWS

Fertilizer materials still in turmoil
A Key Chemicals Review
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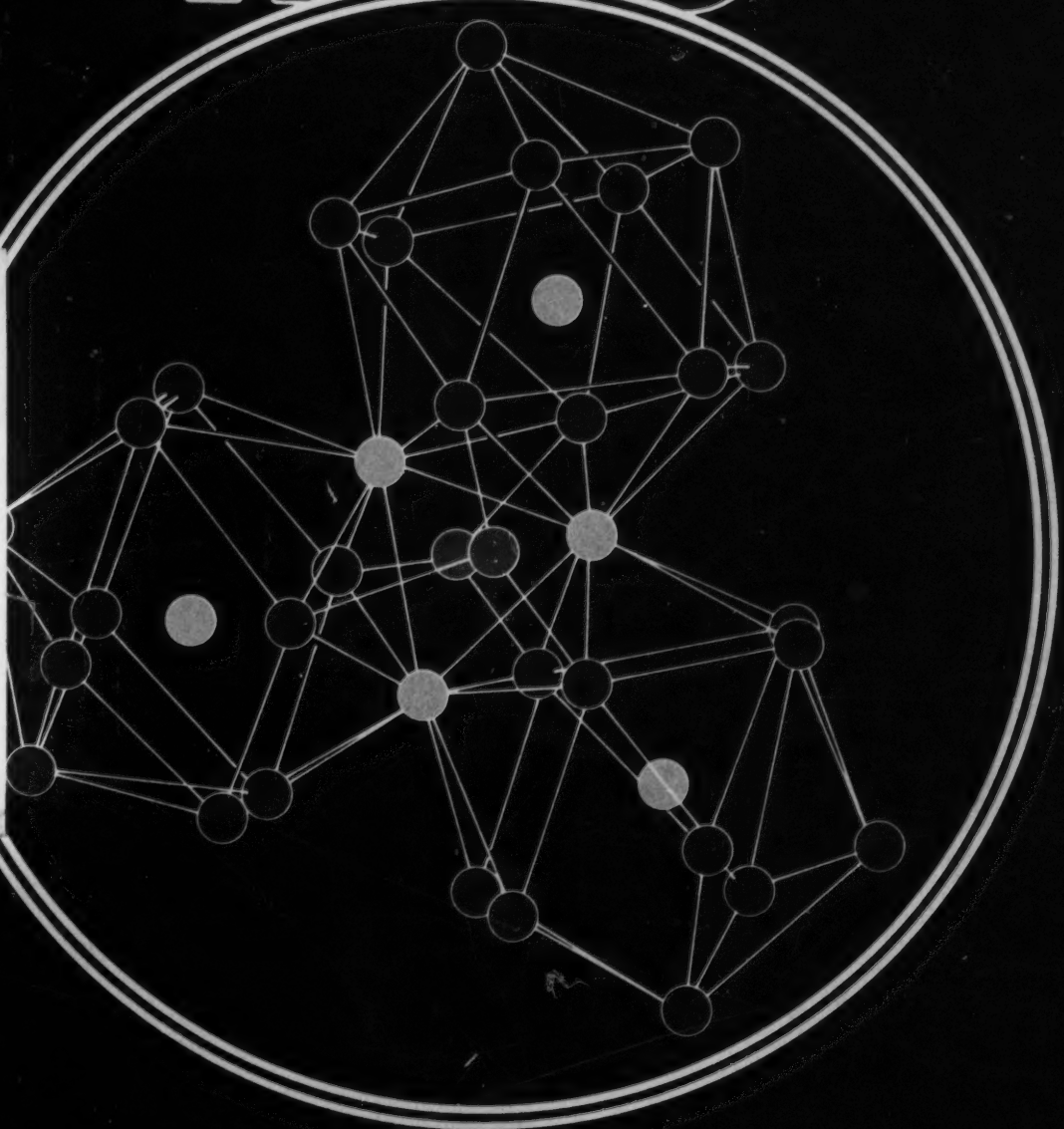

METAL CLUSTERS

Catalytic promise drives research
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CHEMICAL & ENGINEERING
NEWS
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■ **President Reagan's package on competitiveness, recently introduced in the House, gets tepid reception from the chemical industry.** **Page 7**

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■ **Hoechst-Celanese merger clears last major hurdle as Federal Trade Commission conditionally drops antitrust objections to merger.** **Page 8**

Cover: Metal framework of cluster, $[(CH_3C_6H_4)_3P]_{12}Au_{16}Ag_{20}Cl_{14}$, consists of icosahedral units; orange represents silver atoms at top and bottom of cluster, magenta represents remaining silver atoms, blue represents gold atoms on cluster's surface, and yellow-green represents gold atoms inside cluster

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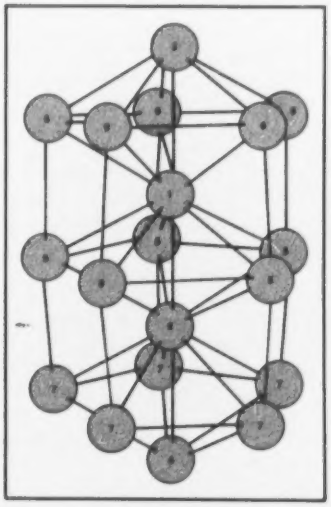


News Focus

Emerging discipline of cluster chemistry holds much promise for catalysis, but its reach extends to theoretical exploration of matter. **Page 9**

Fertilizer Chemicals Face Another Bleak Year

Demand for ammonia, urea, wet-process phosphoric acid, potash will slip as fertilizer consumption is forecast to be less than 42 million tons

Bruce F. Greek, C&EN Houston

Forecasts for lower demand dominate the fertilizer outlook in the U.S. as the spring planting season begins in the South. A decline in total consumption of 5 to 8% in the fertilizer year ending June 30 will send it to below 42 million tons, or to about the 1983 level when the Payment in Kind (PIK) program was used to reduce crop surpluses. About 44.5 million tons of fertilizer were used in the 1986 fertilizer year, down 9% from 1985. Programs to reduce planted acreage will speed this year's decline in U.S. fertilizer use, and thus of the major fertilizer materials—ammonia, urea, wet-process phosphoric acid, and potash.

Fertilizer production, although also down, will be larger than consumption, because of a net export of material over imports. The trade balance has been slipping for some years as imports of fertilizer materials containing nitrogen increased rapidly while exports were slowing. Ammonium nitrate and urea have lost many of their export markets because of new production in other countries, and diammonium phosphate (DAP) is now the largest-volume fertilizer export, in terms of nutrients.

Efforts to reduce production of feed grains, especially corn, will lead to another decline in U.S. fertilizer consumption. Inventories of corn are estimated by the Fertilizer Institute to be more than 5.3 billion bushels by the end of this marketing year in August.

Two programs, currently in place, are designed to reduce feed grain production. One is the Acreage Reduction Program (ARP) used last year, which permitted farmers to participate in price support programs if they would agree not to plant 20% of their land that could be used to grow crops. This program is estimated to have taken about 18 million acres out of production in the 1986 crop year. Apparently it reduced fertilizer demand more than 4.4 million tons.

Key Chemicals

The new program being added to the existing one is called Paid Land Diversion (PLD). That program gives farmers the option of idling up to 15% more of their cropland—in addition to land idled under ARP—in return for a payment of $2.00 per bushel for grain that otherwise would have been grown on the acreage in the PLD. The deadline for farmers to enter the program is March 30, so the final amount of land idled for this year will not be known for some time.

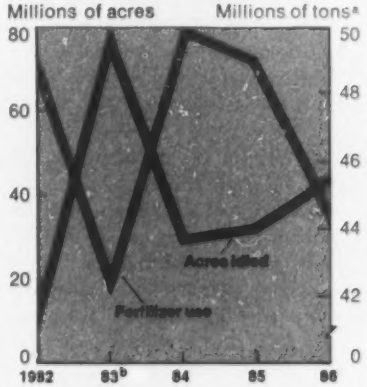
The PLD program might have involved more acreage. At one time, rumors abounded that the additional acreage to be idled would be 30% above the 20% of ARP. Efforts by farm-oriented organizations such as the Fertilizer Institute to oppose another large cut in planted acreage resulted in the 15% level to be used in the PLD. Even so, the 15% level is forecast to reduce cropland another 20 million acres this year and to reduce fertilizer consumption another 2.5 million tons.

The new PLD program was announced late in October 1986, and fertilizer producers have been adjusting plant operations to account for expected lower demand this spring. Some units haven't been restarted following shutdown after the last growing season. Inventories of finished fertilizers also have been reduced, to bring them more in line with anticipated sales this spring.

Prices for most fertilizer materials have returned to levels of a year ago, resulting mainly from slowed production and reduced inventories. Although numerous producers have left the fertilizer business during the past year, plenty of capacity to make these materials remains unused. Such overcapacity coupled with acreage cuts causing lower demand, plus low farm commodity prices which reduce farmers' buying power, will hinder any recovery in the fertilizer business at present.

For details of the near-term outlook for the major fertilizer materials, please see the following pages.

Cuts in planted farm acreage hurt fertilizer use



Note: Crop years ending June 30. [a] Includes secondary and micronutrients. [b] Year of Payment in Kind (PIK) program. **Source:** Fertilizer Institute

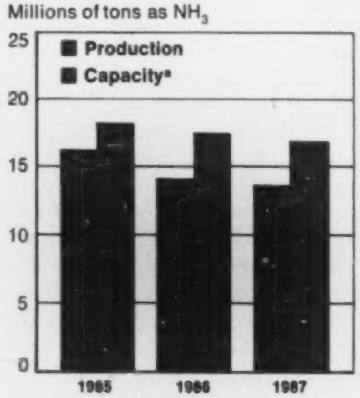
NH_3

Ammonia

- **Output down**
- **Capacity falling**
- **Prices up seasonally**

PRODUCTION/CAPACITY

Millions of tons as NH_3



[a] First quarter; some capacity idle but believed operable.

MAJOR PRODUCERS

CF Industries, Farmland Industries, W. R. Grace, Unocal, Williams Cos. (Agrico)

HOW MADE

Catalytic reaction of nitrogen from air and hydrogen from natural gas

MAJOR DERIVATIVES

Ammonium phosphates 20%, urea 20%, ammonium nitrate 15%, polymer intermediates 10%

MAJOR END USES

Fertilizers 80%, fibers and plastics 10%, explosives 5%

FOREIGN TRADE

Exports holding at about 500,000 tons; imports holding at more than 2.5 million tons

PRICE

$100 to $110 per ton on Gulf Coast

Ammonia production will fall this year, but not so much as last year. Plant capacity also will decline, but, again, less than in 1986. Anhydrous ammonia imports are expected to continue at about the same level as in 1986. However, imports of an ammonia derivative—urea, which competes with ammonia as a fertilizer material—again will increase, unless proposed antidumping regulations are adopted. Ammonia prices, which are now back up to levels of a year ago, may not fall so much as during the second half of 1986, unless reductions in demand (due to lower acreage planted) overexpand inventories.

Preliminary estimates indicate that U.S. ammonia output in 1986 totaled slightly more than 14 million tons, down 2.2 million tons, or about 14%, from 1985 production. Production last year was down more than 5.7 million tons from the peak year of 1980, or almost 30% from that year's total of 19.7 million tons.

Estimates for ammonia production this year vary as much as 500,000 tons on either side of the 14 million tons produced last year. However, most forecasts are for a slight decline because of high imports of ammonia and other nitrogen fertilizers, manufacturing unit closings, and less acreage planted. Nonetheless, a number of positive factors will help to maintain ammonia output, including lower gas prices and a probable increase in the amount of nitrogen fertilizer used per acre. The average decline now expected is less than 2% or about 200,000 tons, bringing the 1987 total to 13.8 million tons.

The amount of operable capacity during the year also is uncertain. For example, as 1987 began, Chevron Chemical mothballed about 500,000 annual tons of ammonia capacity at Pascagoula, Miss. Other capacity also may be idled later, depending on how strong sales are during the spring season, how well prices hold up after the season ends, and how consolidation in the industry proceeds. If 1987 output totals 13.8 million tons, the 17 million tons of available capacity in the first quarter will be run at an average rate of 82%, which is higher than last year's rate but generally below annual rates earlier in the 1980s, many of which were more than 90% of nameplate capacity.

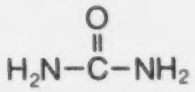
U.S. agricultural consumption of nitrogen as ammonia and its derivatives is forecast to decline 6 to 8% in 1987. The other major use of nitrogen in agriculture—animal feeds—is growing very slowly over the long term. Industrial uses, including explosives and various polymers, will grow little if any this year.

Imports and exports of ammonia and derivatives used in fertilizers are out of balance. This year imports of ammonia are expected to exceed exports by 2 million tons as nitrogen, about the same as last year. Other ammonia derivatives, such as ammonium nitrate and urea, have substantially larger imports than exports. Exports of diammonium phosphate (DAP) are much greater than imports, partially making up for the trade deficit in ammonia, ammonium nitrate, and urea.

With the fertilizer application season nearing its maximum for the year, inventories of ammonia and its derivatives have been built less than normal, according to some industry sources. The reason is the anticipated reduction in use forecast for the year.

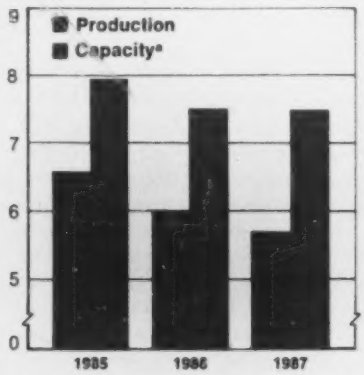
Because of controlled inventory by the middle of last month, prices for ammonia already had moved to more than $100 per ton at plants on the Gulf Coast. The price had fallen to less than $70 per ton during a brief period last fall. Prices of ammonia could rise further next month if immediate consumption of fertilizers increases beyond expectations, if imports do not surge, and if natural gas prices increase. After the demand surge is over, producers will have to decide whether to hold down inventories and keep prices up or to sell at lower prices again.

Urea



- *Production slowing*
- *Capacity on hold*
- *Prices pressured*

PRODUCTION/CAPACITY



a First quarter; some capacity idle but believed operable.

MAJOR PRODUCERS

Arcadian, CF Industries, Farmland Industries, Unocal, Williams Cos. (Agrico)

HOW MADE

Reaction of ammonia and carbon dioxide under pressure

MAJOR DERIVATIVES

Urea-formaldehyde resins 5%

MAJOR END USES

Fertilizers 80%, animal feeds 10%, adhesives and plastics 5%

FOREIGN TRADE

Exports holding at about 1 million tons; imports rising to more than 3.5 million tons

PRICE

$95 to $105 per ton on Gulf Coast

Urea production will be harder hit by imports than any other of the fertilizer materials. Fast-rising imports of urea have led to proposals for antidumping duties, with decisions rumored to be made this month. Output of urea will fall in 1987, but whether the decline will be large or small will depend on how imports are restricted and how prices respond to those restrictions.

The substantial excess of exports of urea over imports in the early 1980s changed in 1983 when urea imports soared and exports fell steeply. In 1986, imports probably approached 4 million tons, up from about 2.2 million tons in 1985 and 1984. Exports declined to less than 1.2 million tons in 1985, and slipped further last year. The net imports of urea in 1986 account for the second largest part of the trade deficit in nitrogen for fertilizers after net imports of ammonia.

U.S. production of urea likely will be down again in 1987, as about a quarter of the year will have passed before any restrictions, other than prices, could be placed on urea imports. The decline in output this year will be about 5% from 1986 to 5.7 million tons. Output last year was down 9% from 1985. The historical high for U.S. urea production occurred in 1981, when slightly less than 8.1 million tons were produced from a little more than 8.1 million tons of capacity.

Operable nameplate capacity for urea in the U.S. currently is about 7.5 million tons per year. Urea plants are located adjacent to ammonia plants, which are the source of the other raw material going into urea—carbon dioxide. Some capacity now running may be shut down after the spring planting season if prices decline because of low-price imports. If production totals 5.7 million tons in 1987, available capacity at the beginning of the year will be run at about 75%, well down from historical performances.

In many instances urea manufacture aids ammonia plant operation, unless urea prices are very low. A manufacturing complex making ammonia, urea, ammonium nitrate (by burning ammonia to make nitric acid, which is reacted with more ammonia), and solutions of urea and ammonium nitrate can be run more efficiently and with a better return than a plant making merchant ammonia alone. Urea-ammonium nitrate (UAN) solutions have been, by far, the fastest-growing fertilizer material of the past five years, because of the ease of application.

Urea provides a source of nonprotein nitrogen in animal feeds. It also is used to make urea-formaldehyde and melamine resins and chemical intermediates. Feed and industrial uses as a group account for less than 20% of urea consumption and are growing marginally.

Therefore, urea consumption hinges on fertilizer demand, with all of the uncertainties due to weather and acreage restrictions. Exports of urea are forecast to decline slightly again this year, but will remain near 1 million tons. How much imports will offset U.S.-produced urea in fertilizer markets could further influence production for the year.

Similar to those of ammonia, prices of urea have recovered to levels of a year ago, or to about $100 per ton at Gulf Coast plants. This price is well above levels of last fall when, for a short period, prices fell to about $75 per ton.

Urea imported from East-bloc countries had been selling for less than $70 per ton at Gulf Coast ports. Some of the imported urea has been poor-quality prilled material with a high dust content, and reportedly dissolves poorly when used to make UAN solutions.

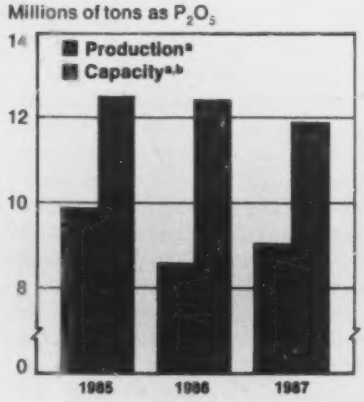
Demand for urea is not expected to rise this year and exports may decline. If urea imports are drastically reduced, the urea not coming into the U.S. will move to countries once supplied by U.S. exports. Therefore, the outlook for U.S. urea production remains flat until domestic fertilizer demand increases significantly.

H_3PO_4

Phosphoric acid

- *Production to recover*
- *Capacity slipping*
- *Prices higher*

PRODUCTION/CAPACITY



a Wet process acid. b First quarter; some capacity idled and not expected to operate again.

MAJOR PRODUCERS

CF Industries, Freeport Chemical, International Minerals, Occidental Agricultural Chemicals, Texasgulf

HOW MADE

Phosphate rock reacted with sulfuric acid, with product phosphoric acid purified and concentrated

MAJOR DERIVATIVES

Ammonium phosphates 85%, triple superphosphate 10%

MAJOR END USES

Fertilizers 95%, animal feeds 5%

FOREIGN TRADE

Exports holding at about 1.2 million tons; imports small, less than 25,000 tons

PRICE

$250 per ton of 100% P_2O_5

Output of wet-process phosphoric acid this year will rise because export demand for a major derivative—diammonium phosphate (DAP)—will increase. But U.S. consumption, mostly in various forms of phosphate and mixed fertilizers, will decline again because planted acreage will be smaller, according to forecasts for the 1987 crop year ending June 30. These developments will combine to hold phosphoric acid output well below the 1985 level.

Uncertainties, however, cloud the forecasts. For example, some speculate that the relatively warm winter and an early spring will result in a higher application rate per acre and thus spur fertilizer demand this year in spite of plans to reduce planted acreage. There also is a question of export demand for DAP, because of uncertainties about inventories in countries such as India and China that in recent years have imported large quantities of DAP. These and other influences on demand could cause variations in output of wet-process phosphoric acid as large as 1 million to 2 million tons as P_2O_5 or more than 20%.

Phosphoric acid output this year probably will exceed 9 million tons as P_2O_5. About 400,000 additional tons of "furnace" or "thermal" phosphoric acid will be made by burning elemental phosphorus produced in an electric furnace. This acid will be consumed in detergent materials, foods, beverages, and other nonfertilizer uses for which high purity is important. "Wet acid" production will be about 500,000 tons higher than the estimated 1986 production of 8.6 million tons, an increase of about 6%. The 1986 output of wet-process phosphoric acid fell 14% from the 9.9 million tons produced in 1985. That decline continued and accelerated the decline that began after 1984's record production of 10.7 million tons.

Capacity to make wet-process phosphoric acid also has been declining. Not only have obsolete plants been shut down, but other capacity has been closed as a result of mergers and bankruptcies. Expansions of capacity during the past two years have been meager, less than 500,000 tons of annual capacity as P_2O_5. At the beginning of 1987, operable capacity totaled about 12 million tons as P_2O_5, yet nearly a quarter of this capacity was idle, and only part of the idled capacity is expected to be run this spring to meet both domestic and export demand for phosphate fertilizer materials.

For all of the calendar year, the average plant operating rate will be barely more than 75%. This rate, and the 1986 rate of less than 70% of the available capacity as that year began, contrasts sharply with operating rates of close to 100% that once were considered typical for the wet-process phosphoric acid industry.

The low operating rates resulted in a spate of changes of ownership and operations in the phosphoric acid industry. The complex dealings of Freeport-McMoRan through its subsidiaries is one example. Last month, Freeport-McMoRan Resource Partners, a limited partnership, finalized an agreement to buy Agrico Chemical, the fertilizer producing company owned by Williams Cos., with closing scheduled later this year. Earlier, Freeport had moved to acquire a phosphoric acid plant and phosphate rock mine from Beker Industries. Freeport previously had bought a plant to make DAP. These moves, if all are completed, could make Freeport second in capacity size as a producer of phosphoric acid and would make the company a large basic producer of ammonia.

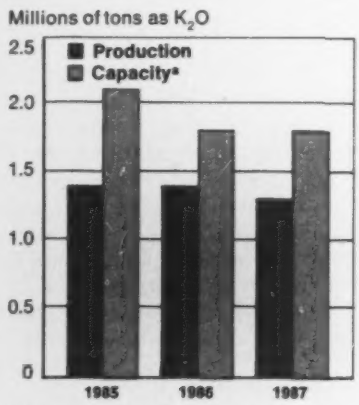
After declining rapidly during 1986, prices for phosphoric acid currently have moved back to about the levels of a year ago. Sulfur prices declined last fall, which helped phosphoric acid margins. But with corn and cotton plantings forecast to be down 7 to 10% this year, prices again could decline unless inventories are controlled and held at the relatively low levels of the beginning of the year.

KCl, K_2SO_4, $K_2SO_4 \cdot 2MgSO_4$

Potash

- ***Production to decline***
- ***Capacity down***
- ***Prices up slightly***

PRODUCTION/CAPACITY



a First quarter; some capacity idle, restarting uncertain.

MAJOR PRODUCERS

AMAX, International Minerals, Lundberg Industries, Texasgulf, Vertac Fertilizer & Minerals (New Mexico Potash)

HOW MADE

Shaft and solution mining of potassium salts, mainly the chloride, and subsequent purification

MAJOR DERIVATIVES

Various potassium salts 5%

MAJOR END USES

Fertilizers 95%

FOREIGN TRADE

Exports holding at about 500,000 tons as K_2O; imports may decline slightly from more than 4 million tons as K_2O

PRICE

$50 to $60 per ton at mining sites

U.S. potash production and consumption again will fall in 1987. The rate of decline for both measures will be about the same, but in terms of volume production will decline much less than consumption. Imports will account for more than 80% of U.S. consumption. No important changes in potash capacity are forecast for this year.

This year's decline in agricultural potash consumption will result from cuts expected in acreage planted this spring as part of programs to reduce crop surpluses. In the fertilizer year ending this June 30, consumption of materials containing potassium is estimated to total 4.5 million to 4.6 million tons as K_2O, down from the 5.03 million tons consumed in the 1985 fertilizer year. This will be the first year since 1983 that consumption has fallen below 5 million tons, and it could be the lowest since 1975.

U.S. production of potash during calendar year 1987 also is expected to decline about 8%, to less than 1.3 million tons as K_2O. It will be down about 100,000 tons from 1986 output, estimated to be slightly below 1.4 million tons, and from 1985 output of 1.43 million tons.

Potash capacity in the U.S. is concentrated around Carlsbad, N.M., and has been declining for some time. The quality of ore available continues to fall, causing mining and other costs to rise. Production costs have increased faster than selling prices, which are pressured by lower-cost production at other locations. Some mines have been closed. Mines and other facilities currently believed capable of potash production have a combined capacity of about 1.8 million tons per year as K_2O. Some of the capacity was not operating as 1987 began. Based on an anticipated U.S. output of 1.3 million tons, the operating rate for 1987 may average 72%.

About 4 million tons of potash as K_2O will be imported in 1987, mainly from Canada, to meet anticipated U.S. demand. Exports of U.S.-produced potash are expected to be about 500,000 tons in 1987. These exports go to such places as South America because transportation costs from New Mexico are lower than from Canada. In addition to exports to the U.S., Canadian producers, many of which are subsidiaries of U.S. firms, export another 2.0 million to 2.5 million tons per year of potash to other countries.

Like other fertilizer materials, potash also is in worldwide overcapacity. Global capacity is estimated to be 40 million metric tons as K_2O; 1986 output is estimated to have been more than 29 million metric tons. Inventory building last year apparently was large, possibly more than 2 million metric tons. This put pressure on prices everywhere and caused wide variations in shipments to various consuming countries outside North America.

Some new capacity to produce potash has started up in eastern Canada in the province of New Brunswick. Other mining and processing facilities have been proposed for the same area, the first Canadian facilities outside Saskatchewan. Most of this potash is destined for export markets, some of which are in the eastern U.S. The mines have relatively large capacities because investment costs require that economics of scale be large.

Besides use as a fertilizer material, some potash—estimated to range from 300,000 to 400,000 tons per year—is consumed in making various chemicals in the U.S. and Canada. The industrial uses of potash are mainly specialties and, as a group, are not growing very fast in their needs for potash raw material.

With the current situation in fertilizer demand, the near-term prospects for U.S. potash production are for small declines. Longer term, agricultural use could return to the levels of the early 1980s. By that time, however, new Canadian sources could have production costs so far below those for New Mexico operations that more capacity reductions will occur there.

Strong Rise Forecast in Global Uranium Demand

Key is rapid expansion in nuclear power stations, whose electricity-generating capacity by 2000 may reach 373 gigawatts, up 63% from 1986

Dermot A. O'Sullivan, C&EN London

Taken at face value, the near-term prospects for uranium suppliers seem reasonably good, according to the Uranium Institute. In its latest review (the fourth to date) of the global uranium market, the London-based institute projects demand at the end of the 20th century to fuel commercial nuclear electricity-generating stations throughout the noncommunist countries at about 52,000 metric tons, an increase of almost 24% from the 42,000 metric tons or so used last year.

The Uranium Institute was set up in 1975; its members comprise a number of bodies with interests in the nuclear fuel cycle in Australia, Belgium, Brazil, Canada, Finland, France, Gabon, Italy, Japan, Namibia, South Africa, Spain, Sweden, Switzerland, Taiwan, the U.K., the U.S., and West Germany, as well as Euratom, a sister organization of the European Economic Community.

In the year 2000, West European uranium use will account for 40% (20,800 metric tons) of the global noncommunist total. Next will come the U.S. with 27% (14,300 metric tons), followed by the Far East with 24% (12,500 metric tons). The 9% balance (4700 metric tons) will be shared by other countries.

This uranium demand profile will differ somewhat from last year's. Then, Western Europe took 44% (18,800 metric tons), and the U.S. nearly 35% (14,700 metric tons). The Far East accounted for only 15% (6400 metric tons). The 6% balance (2400 metric tons) went to other countries.

The anticipated rise in uranium demand is based on the rapid expansion in nuclear-fueled power stations foreseen in the years leading up to the 21st century. According to the institute's data, which have been gleaned from various government and industry sources, overall nuclear electricity-generating capacity by 2000 might reach 373 gigawatts (GW), 63% more than last year.

In Japan, for instance, the rise will be close to 141%, from about 25 to 59 GW. In France, a 77% increase is being predicted to 68 GW in 2000, at which level nuclear's share will stand at 78% of France's total electrical energy output. For the U.S., there will be a more modest 28% or so expansion to 111 GW by 2000. On the other hand, the 87-GW installed nuclear capacity in 1986 (some 16% of the U.S. electricity total) far exceeded that in any other country.

Significant as the projected rise in nuclear generating capacity may appear, the growth has been trimmed from the Uranium Institute's earlier predictions. Compared with those made in the second review, in 1981, and the third, in 1984, the forecast total for 1990 dropped 16%, from 352 to 295 GW. The current review's figure of 292 GW in 1990, however, is only down 1% from the projection made in 1984. "It is, therefore, regarded as a relatively secure estimate," the institute's analysts contend. "The nuclear industry appears to be entering a period of stability.

"The estimate for 1995 has been progressively revised downward from the 1981 forecast, first by 18% in 1984, and then by a further 8% to 331 GW in 1986. This decrease reflects the higher number of units for 1995 that were under construction or on order in 1981 or 1984, but were deferred or canceled by 1986.

"For the year 2000, which was not covered in previous reports, few possible shutdowns, delays, or cancellations as a result of the 1985 Chernobyl accident in the Soviet Union have been incorporated. At the time of writing, it was too soon after the accident to allow reliable judgments to be formed."

The institute's analysts concede that it is difficult to assess all the possible effects of the accident. Some long-term consequences are inevitable. Even though it was caused primarily by human error, new safety measures could be required for all reactors, especially for those that don't have containment buildings. It also is likely that nuclear plants in some countries may be shut down, deferred, or canceled, reflecting a change in public attitude to nuclear power.

"The underlying assumption of this report is that operating nuclear generating plants will not be shut down, and those under construction in 1986 will be completed," the institute maintains. "If from 1986 no new reactor orders were placed as a result of Chernobyl, 1995 installed nuclear capacity would be about 2% less than the forecast of 331 GW. By the year 2000, if there were no new orders, projected capacity would be about 328 GW, some 12% lower than the estimate of 373 GW."

Chernobyl apart, there are other factors to be taken into account, the interplay of which affects decisions by governments on whether to extend nuclear generating capacity. For instance, as a result of the recent decline in oil and coal prices,

short-term economics could delay construction, especially where there is some excess fossil fuel electrical-generating capacity. And there are noneconomic aspects, such as the environmental impact of a nuclear energy source, the disposal of radioactive waste, and the like, that will influence investment decisions.

The Uranium Institute acknowledges that "the amount of future nuclear generating capacity could vary depending on the interplay of economic growth, interfuel competition, and factors such as concerns about nuclear waste and changes in public opinion about nuclear energy." But it makes the point that "This report's analysis shows that in the long term, nuclear power is expected to retain its economic advantage for generating electricity in most areas. Furthermore, the prices at which utilities would consider using excess fossil fuel capacity in preference to nuclear plants are below the 1986 marginal production costs for coal and oil."

As nuclear power generation expands, demand for uranium to fuel the plants also increases. However, the two don't grow exactly in step. On the one hand, uranium requirements change some two years in advance of the corresponding changes in generating capacity because of the lead time needed for the uranium to be processed into fuel. In addition, most utility companies maintain a fuel stockpile over and above what they have undergoing conversion, enrichment, and fabrication. These stocks are intended as an insurance against supply disruption.

The institute's report estimates that global consumer inventory at the beginning of last year was 120,000 metric tons of uranium. That represents about 40% more material than is needed to sustain two years' forward requirement. Procurements, therefore, are expected to be lower than actual need until 1991, when the aggregate excess fuel inventories are expected to be utilized. Purchases are forecast to be 41,600 metric tons in 1990, 48,500 metric tons in 1995, and 51,700 metric tons in 2000.

Other factors enter into the equation for making forward projections of fuel demand. Developments in the industry, driven by economic pressures, offer a number of ways of saving uranium. Examples are the more extensive use of recycling technology, and improved fuel management techniques. Combined, they could reduce requirements in 1995 about 14%, and in 2000 about 20% below those needed in their absence.

"The extent to which they will be used introduces uncertainty into projections for reactor requirements—the uranium needed to fuel reactors," the report admits. "Both reactor requirements and uranium procurements (uranium purchases intended by reactor operators each year) will tend to increase somewhat more slowly than the growth of western nations' installed nuclear capacity. The result is that actual demand may turn out to be somewhere between the estimates for reactor requirements, and those for uranium procurements."

On this basis, the institute's forecasters have adjusted downward their demand projections. In 1990, for instance, they calculate that uranium demand could be 42,700 metric tons, 4% less than the theoretical need after taking account of fuel management improvements, etc. Likewise, in 2000 it might be 48,600 metric tons, 7% less than expected.

In the past, uranium producers have always been able to supply what have been perceived at the time as the potential needs of western nations' nuclear industry. Output rose steadily throughout the 1970s, peaking in 1980 at 44,000 metric tons. Since then, it has been on the decline to a level of 34,700 metric tons in 1985—the latest year for which data are available.

The 21% fall in production between 1980 and 1985 masks much greater changes that have taken place on a regional basis. The U.S. until a few years ago was the biggest source of uranium. Output at its height in 1980 stood at 16,800 metric tons, some 38% of the noncommunist world total that year. By 1985, it had declined 75% to 4200 metric tons. Canada, in the meantime, has emerged as the largest producer. Its 1985 output of almost 11,000 metric tons accounted for a third of western nations' total. South Africa came second with nearly 5000 metric tons. □

Uranium demand in 2000 will be about 20% higher . . .

Thousands of metric tons	1986	1987	1988	1989	1990	1995	2000	Change 1986–2000
Western Europe	18.8	19.6	19.5	19.6	19.3	20.4	20.8	10.6%
U.S.	14.7	14.4	14.6	14.5	14.2	14.2	14.3	−2.7
Far East	6.4	6.8	7.2	7.5	7.8	10.7	12.5	95.3
Others[a]	2.4	2.5	2.7	2.8	3.2	4.1	4.7	95.8
TOTAL	42.3	43.3	44.0	44.4	44.5	49.4	52.3	23.6%
ADJUSTED TOTAL[b]	41.3	42.3	42.9	43.0	42.7	45.4	48.6	17.7%

. . . to meet prospective rise in nuclear generating capacity

Gigawatts	1986	1987	1988	1989	1990	1995	2000	Change 1986–2000
U.S.	86.6	97.6	104.3	105.5	106.6	108.9	111.2	28.4%
France	38.2	44.2	48.3	51.5	54.0	62.9	67.7	77.2
Japan	24.5	27.9	28.7	29.3	31.5	49.0	59.0	140.8
West Germany	17.6	19.2	19.2	21.7	23.0	23.0	24.3	38.1
Canada	10.8	11.6	11.6	12.5	13.4	15.8	15.8	46.3
U.K.	9.8	11.0	12.3	12.3	12.3	11.4	13.8	40.8
Sweden	9.6	9.6	9.6	9.6	9.6	9.6	9.6	0.0
Belgium	5.5	5.5	5.5	5.5	5.5	6.7	6.7	21.8
Spain	5.5	5.5	6.5	7.5	7.5	8.4	10.3	87.3
Others[a]	20.8	22.8	23.6	24.7	28.3	34.8	54.5	162.0
TOTAL	228.9	254.7	269.8	280.1	291.7	330.5	372.9	62.9%

a Noncommunist countries, but excluding Yugoslavia. b Total allowing for recycling of reprocessed fuels.
Source: Uranium Institute